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(19) (CA) **CANADIAN PATENT** (12)

(54) Cathodic Protection System for Reinforced Concrete
Including Anode of Valve Metal Mesh

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ABSTRACT

The invention relates to extended area electrodes and in particular anodes and anode connectors. Such anodes are useful in various applications such as impressed current cathodic protection systems, electro-osmosis of water logged areas and electro damp-proofing. Some anode materials such as copper are rapidly consumed while metals of the platinum group are substantially unaffected but are expensive. The anode of the invention comprises a plurality of wires of valve metal in the form of an open mesh, the wires having on their surface a material such as a platinum group metal which has anodically active properties. The mesh structure, which may be used as a connector to a further electrode body such as coke, conductive concrete or paint, etc., may be formed by weaving, knitting, or a network of strands which are welded together.

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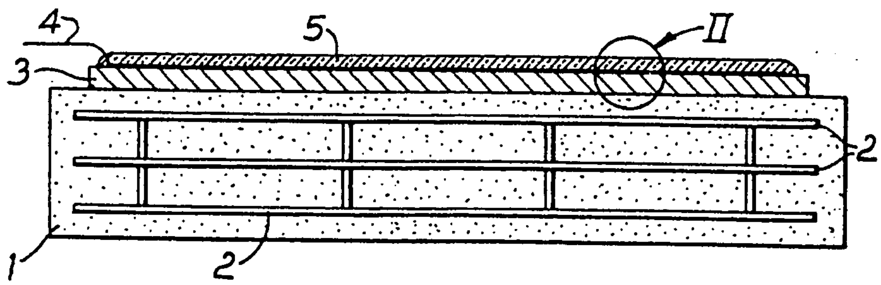

Fig. 1

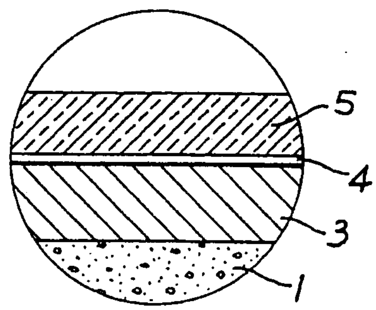

Fig. 2

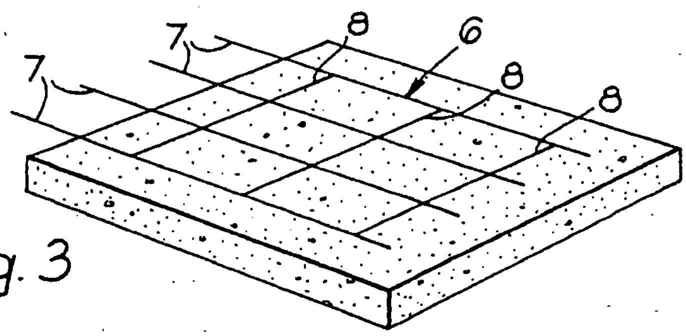

Fig. 3

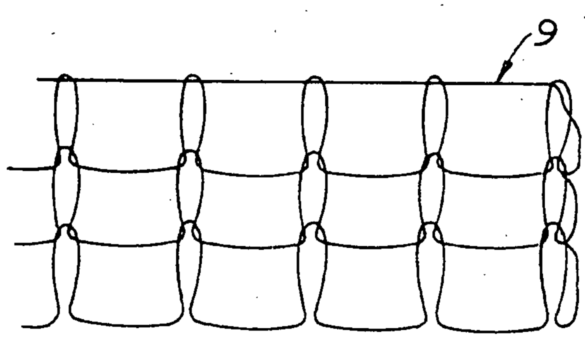

Fig. 4

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This invention relates to electrodes and has particular reference to extended area electrodes.

Electrodes are used in many applications and the invention is particularly concerned with the provision of anodes and anode connectors.

It is well known to use anodes in impressed current cathodic protection systems particularly those involving the protection of a steel structure immersed in water. Essentially in such an arrangement the structure is made cathodic relative to an anode to prevent oxidation of the steel structure i.e. to prevent rusting. The chemical reaction taking place at the anode is, in the case of an impressed current system, the evolution of oxygen.

It is well known that certain materials when connected as anodes will rapidly dissolve. Such materials may be used as consumable electrodes but cannot be used as non-consumable electrodes for impressed current systems. Thus it is not possible to use copper in a commercial impressed current system as an anode because it would dissolve. Other materials, such as metals of the platinum group, are substantially unaffected when connected as an anode.

*

Such materials evolve oxygen and only very slowly dissolve. ~~the~~ The wear rate frequently quoted for platinum in an aqueous sodium cloride solution is one microgram per ampere hour. This means that one microgram of platinum dissolves for each ampere hour of current area passed. Such low wear rates gives rise to platinum anodes being considered as non-consumable. However such terms as non-consumable are really relative and when used herein the terms non-consumable and substantially non-consumable are used to mean a material which is consumed at such a low rate as to be economically useful as an anodically active material in transferring electrons to an electrolyte.

The metals and compounds of the platinum group are classically used in cathodic protection systems as non-consumable surfaces. The platinum group metals are frequently used as a thin layer on a valve metal because of the cost of the platinum group metal itself.

Other materials such as lead dioxide may be used as non-consumable anode surfaces since they are relatively inexpensive and the higher wear rates associated with their use can be compensated by the use of thicker coatings.

When used in sea water it is possible to operate an anode at a high current density because the throwing power of the anode, i.e. the volume which could be electronically influenced by the anode, is high as the electrical conductivity of sea water is high.

There has recently developed a need to produce an anode capable of operating economically at low current densities. It is fairly clear that any anode

which can be operated at a high current density could in fact be operated at a low current density. However the cost of platinum coated anodes is relatively high and the economic viability of their use has in the past depended on their being operated at high current densities.

In the case of cathodic protection ~~or~~ of reinforcement bars (rebars) in reinforced concrete the concrete itself must carry the electrical current to the rebars which are cathodically protected relative to an externally applied anode. The need in such a system is for an anode having an extensive surface area in contact with a large area of concrete because the throwing power of the anode through the concrete is very low. There is, therefore, a need for an anode in such a situation which can operate at a low current density and will be economically provided at a cost which will enable it to be used commercially.

There are other applications for the use of anodes operating at low current densities and having extended areas. The range of such applications is wide and includes electro-osmosis to remove water from water-logged slag heaps, railway sidings, land drainage and other civil engineering applications and electro damp-proofing to damp-proof buildings.

By the present invention there is provided an extended area electrode comprising a plurality of wires of valve metal in the form of an open mesh, the wires having on their surface a material having anodically active properties, the material being substantially non-consumable in operation.

The material on the surface may be in the form of a coating.

The invention herein comprises a cathodic protection system for the cathodic protection of reinforcement bars in reinforced concrete which comprises reinforced concrete containing reinforcement bars, and an anode in electrical connection with the concrete which anode comprises a plurality of wires of valve metal in the form of an open mesh, the wires having on their surface a coating of material having anodically active properties, the material being substantially non-consumable in operation.

The mesh may be in contact with a further anodically active material which is in electrical contact with the concrete, the further anodically active material being selected from electrically conductive concrete, electrically conductive plastics material, electrically conductive paint, graphite, electrically conductive coke and electrically conductive bitumen. Where electrically conductive plastics material is used, this may be in the form of a sheet having the mesh embedded therein.

The anodically active coating may be a platinum metal or platinum group metal compound or may comprise a doped layer of an oxide of a valve metal. Alternatively the anodically active layer may comprise lead or lead oxide or a sub-stoichiometric tin oxide or antimony oxide.

The mesh structure may be formed by weaving or knitting or may comprise a welded structure in the form of a network of individual strands welded together where they cross.

The valve metal wires may be provided with a core of a metal of higher electrical conductivity than the valve metal, preferably a copper or aluminium core.

The present invention also envisages the use of such an electrode as a connector to a further electrode body such as coke, electrically conductive bitumen, electrically conductive plastics material or electrically conductive cement. The electrically conductive plastics material may be in the form of a sheet with the mesh embedded therein. The mesh may have a plurality of holes in its surface.

The present invention further provides a cathodic protection system for the cathodic protection of reinforcement bars in reinforced concrete comprising an anode in electrical connection with the concrete wherein the anode comprises a mesh of wire of a valve metal chosen from the group titanium, zirconium, niobium, hafnium and tantalum or alloys based thereon having comparable anodic properties, the wire having on at least part of its surface an anodically active coating of substantially non-consumable material.

The mesh may be in contact with a further anodically active anode material such as electrically

conducting concrete, electrically conducting plastics material, electrically conductive paint, graphite or electrically conducting coke. The electrically conducting plastics material may have the mesh embedded therein.

The mesh may be knitted or woven or may be a welded structure. The thickness of the wires may be different in different portions of the net. The wires may have a core of a metal of higher electrical conductivity than the valve metal, preferably a copper or aluminium core.

By way of example, embodiments of the present invention will now be described with reference to the accompanying drawings in which:

Figure 1 is a schematic sectional view of a cathodically protected reinforced concrete beam;

Figure 2 is an enlargement of the portion of Figure 1 within the circle II of Figure 1;

Figure 3 is a perspective view of an embodiment in which a wire mesh is connected directly to a concrete slab; and

Figure 4 is a schematic view of a knitted wire mesh.

Referring to Figure 1, this shows a concrete beam 1 reinforced by a series of steel reinforcement bars or rebars 2. Although theoretically the rebars when surrounded by an alkaline cement should not rust or

corrode, it has been found that corrosion of rebars can take place. It is thought that the most common causes of rebar corrosion are either that the concrete contained chloride ions when it was manufactured or that the application of chloride ions to the outside of the concrete has resulted in penetration of chloride ions to the rebars and their subsequent corrosion. This is a particular problem with bridge decks and their concrete supports where the bridges have been salted for safety reasons throughout the ice and snow season of the year.

Because the electrical conductivity of the concrete of the beam 1 is low, any attempt to cathodically protect the rebars must use an extended surface area anode which is capable of throwing its current across the portion of the concrete beam between the anode and the rebar 2. A single anode at one end of the concrete beam would have insufficient throwing power to protect the rebars throughout the entire concrete beam.

As shown in the Figure 2 embodiment, therefore, a graphite slab 3 is bonded to the concrete beam 1 to act as an anode. It is, however, necessary to provide an electrical connection with the graphite layer 3, which can itself be quite difficult to accomplish. As shown in Figure 1 this electrical connection is by means of a platinum clad niobium wire mesh 4 which is bonded to the graphite slab 3 by means of an adhesive layer 5. By using a wire mesh, an extensive area of contact can be produced which enables the anode to operate satisfactorily for long periods of time.

The best form of wire from which to manufacture the mesh comprises a platinum clad niobium wire having a copper core. Such a wire is preferably

formed by co-extrusion in accordance with the method set-out in British Patent No. 1 457 511.

Such a co-extruded wire can be formed with a well bonded platinum layer which platinum layer is pore free, is acid resistant and protects the underlying valve metal. The wire is also smooth and easy and safe to handle.

In the event of failure of the anode layer 3 the wire netting will itself function as an anode to continue to protect the rebars 2. Thus the electrical connector nature of the wire mesh 4 serves a double function of forming the electrical connection to the main anode material and being a back-up in the event of failure of the main anode 3.

As shown in the Figure 3 embodiment, the wire mesh anode 6 may comprise a series of parallel strands 7 crossed by transverse strands 8 and is in direct electrical connection with the concrete. Thus, in this embodiment there is no graphite layer, the mesh acting as the sole anode. The transverse strands need not be formed of platinised metal but may comprise a valve metal without the platinum layer. The valve metal of the wire mesh anode may be chosen from the group titanium, zirconium, niobium, hafnium, and tantalum or alloys based thereon having comparable anodic properties. The wire may have on at least part of its surface anodically active coating.

In place of the platinum metal other anodically active coatings such as lead, lead dioxide or sub-stoichiometric or doped oxides of titanium or tantalum can be used. Because of the low current densities involved, such doped oxides - the doping may

comprise partial removal of oxygen atoms - could be acceptable as anodically active layers.

In addition to the provision of a copper core within the wires, a steel core could be provided for enhanced strength.

The platinum group metal layers may be in the form of platinum or iridium, or iridium containing layers may be used. Electroplating may be used to provide the

platinum group metal layer or fired coatings may be used formed by the application of a paint containing a platinum group compound to the wires and subsequently fired. A titanium palladium alloy such as Ti and 0.15% Pd may be used to form the wires as such a material is both anodically active and electrically conducting and may be used in place of anodically coated titanium alloys.

In addition to the protection of rebars in the concrete the extended area electrode may be used for the electro-osmosis of water logged slag heaps, railway sidings, land drainage, desalting and other civil engineering applications. For large areas of mesh knitting provides a suitable method of manufacturing an open mesh. As shown in Figure 4 an open mesh may be provided from a knitted wire structure 9.

The extended area electrode may be used for electro damp-proofing by being bonded to brickwork or stone work sited a short distance away from the structure to be damp-proofed and set directly into the ground. Under the influence of an applied electric field, water is electro-osmotically attracted towards the cathode and dries out the brick-work.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A cathodic protection system for the cathodic protection of reinforcement bars in reinforced concrete which comprises reinforced concrete containing reinforcement bars, and an anode in electrical connection with the concrete with anode comprises a plurality of wires of valve metal in the form of an open mesh, the wires having on their surfaces a coating of material having anodically active properties, the material being substantially non-consumable in operation.

2. A cathodic protection system as claimed in claim 1 in which the mesh is in contact with a further anodically active material which is in electrical contact with the concrete.

3. A cathodic protection system as claimed in claim 2 in which the further anodically active material is selected from electrically conductive concrete, electrically conductive plastics material, electrically conductive paint, graphite, electrically conductive coke and electrically conductive bitumen.

4. A cathodic protection system as claimed in claim 3 in which the electrically conductive plastics material is in the form of a sheet having the mesh embedded therein.

5. A cathodic protection system as claimed in claim 1 in which the coating comprises a platinum group metal or a platinum group metal compound or a doped layer of an oxide of a valve metal.

6. A cathodic protection system as claimed in claim 1 in which the coating comprises lead or lead oxide or a sub-stoichiometric tin oxide or antimony oxide.

7. A cathodic protection system as claimed in any one of claims 2, 5 and 6 in which comprises a woven or knitted mesh or a welded structure in the form of a network of individual strands welded together where the strands cross.

8. A cathodic protection system as claimed in claim 1 in which the valve metal wires are provided with a core of a metal of higher electrical conductivity than the valve metal.

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